

# Claims

- [c1] 1.A storage virtualization computer system comprising:  
a host entity for issuing IO requests;  
an external storage virtualization controller coupled to  
said host entity for executing IO operations in response  
to said IO requests; and  
at least one physical storage device(PSD), each coupled  
to the storage virtualization controller through a point-  
to-point serial-signal interconnect, for providing storage  
to the storage virtualization computer system through  
the storage virtualization controller.
- [c2] 2.The storage virtualization computer system of claim 1  
wherein said point-to-point serial-signal interconnect is  
a Serial ATA IO device interconnect.
- [c3] 3.The computer system of one of claims 1 and 2,  
wherein a said at least one PSD comprises a SATA PSD.
- [c4] 4.The computer system of one of claims 1 and 2,  
wherein a said at least one PSD comprises a PATA PSD  
and a serial-to-parallel converter is provided between  
said device-side IO device interconnect controller and  
said PATA PSD.

- [c5] 5.The computer system of one of claims 1 and 2 further comprising a detachable canister attached to said storage virtualization controller for containing a said at least one PSD therein.
- [c6] 6.The computer system of one of claims 1 and 2, wherein a said at least one PSD can be detached from said storage virtualization controller when said storage virtualization controller is on-line.
- [c7] 7.The computer system of one of claims 1 and 2, wherein a said at least one PSD can be attached to said storage virtualization controller when said storage virtualization controller is on-line.
- [c8] 8.The computer system of one of claims 1 and 2, wherein said storage virtualization controller is configured to define at least one logical media unit consisting of sections of at least one said PSD.
- [c9] 9.The storage virtualization computer system of one of claims 1 and 2 wherein said storage virtualization controller comprises:  
a central processing circuitry for performing IO operations in response to said IO requests of said host entity;  
at least one IO device interconnect controller coupled to said central processing circuitry;

at least one host-side IO device interconnect port provided in a said at least one IO device interconnect controller for coupling to said host entity; and  
at least one device-side IO device interconnect port provided in a said at least one IO device interconnect controller for coupling to a said at least one physical storage device.

[c10] 10.The storage virtualization computer system of claim 9 wherein a said host-side IO device interconnect port and a said device-side IO device interconnect port are provided in the same IO device interconnect controller.

[c11] 11.The storage virtualization computer system of claim 9 wherein a said host-side IO device interconnect port and a said device-side IO device interconnect port are provided in different IO device interconnect controllers.

[c12] 12.The computer system of one of claims 1 and 2, wherein said storage virtualization controller comprises a plurality of host-side IO device interconnect ports each for coupling to a host-side IO device interconnect.

[c13] 13.The computer system of claim 12, wherein said storage virtualization controller is configured to present redundantly a logical media unit on at least two of said plurality of host-side IO device interconnect ports.

- [c14] 14. The computer system of claim 9, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting point-to-point connectivity in target mode.
- [c15] 15. The computer system of claim 9, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting private loop connectivity in target mode.
- [c16] 16. The computer system of claim 9, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting public loop connectivity in target mode.
- [c17] 17. The computer system of claim 9, wherein at least one said host-side IO device interconnect port is parallel SCSI operating in target mode.
- [c18] 18. The computer system of claim 9, wherein at least one said host-side IO device interconnect port is ethernet supporting the iSCSI protocol operating in target mode.
- [c19] 19. The computer system of claim 9, wherein at least one said host-side IO device interconnect port is Serial-Attached SCSI (SAS) operating in target mode.
- [c20] 20. The computer system of claim 9, wherein at least one said host-side IO device interconnect port is Serial ATA

operating in target mode.

- [c21] 21.A storage virtualization subsystem for providing storage to a host entity, comprising:  
an external storage virtualization controller for connecting to the host entity and executing IO operations in response to IO requests issued from said host entity; and  
at least one physical storage device, each coupled to the storage virtualization controller through a point-to-point serial-signal interconnect, for providing storage to the host entity through the storage virtualization controller.
- [c22] 22.The storage virtualization subsystem of claim 21 wherein said point-to-point serial-signal interconnect is a Serial ATA IO device interconnect.
- [c23] 23.The storage virtualization subsystem of one of claims 21 and 22 wherein said storage virtualization controller comprises:  
a central processing circuitry for performing IO operations in response to said IO requests of said host entity;  
at least one IO device interconnect controller coupled to said central processing circuitry;  
at least one host-side IO device interconnect port provided in a said at least one IO device interconnect controller for coupling to said host entity; and  
at least one device-side IO device interconnect port pro-

vided in a said at least one IO device interconnect controller for coupling to a said at least one physical storage device.

- [c24] 24. The storage virtualization subsystem of claim 23 wherein a said host-side IO device interconnect port and a said device-side IO device interconnect port are provided in the same IO device interconnect controller.
- [c25] 25. The storage virtualization subsystem of claim 23 wherein a said host-side IO device interconnect port and a said device-side IO device interconnect port are provided in different IO device interconnect controllers.
- [c26] 26. The storage virtualization subsystem of claim 23, wherein a said at least one PSD comprises a SATA PSD.
- [c27] 27. The storage virtualization subsystem of claim 23, wherein said storage virtualization controller comprises a plurality of host-side IO device interconnect ports each for coupling to a host-side IO device interconnect.
- [c28] 28. The storage virtualization subsystem of claim 23, wherein said storage virtualization controller is configured to define at least one logical media unit consisting of sections of said at least one PSD.
- [c29] 29. The storage virtualization subsystem of claim 27,

wherein said storage virtualization controller is configured to present redundantly a logical media unit on at least two of said plurality of host-side IO device interconnect ports.

- [c30] 30. The storage virtualization subsystem of claim 23, wherein said at least one PSD comprises a PATA PSD and a serial-to-parallel converter is provided between said device-side IO device interconnect controller and said PATA PSD.
- [c31] 31. The storage virtualization subsystem of claim 23 further comprising a detachable canister attached to said storage virtualization controller for containing a said PSD therein.
- [c32] 32. The storage virtualization subsystem of claim 23, wherein a said at least one PSD can be detached from said storage virtualization controller when said storage virtualization controller is on-line.
- [c33] 33. The storage virtualization subsystem of claim 23, wherein a said at least one PSD can be attached to said storage virtualization controller when said storage virtualization controller is on-line.
- [c34] 34. The storage virtualization subsystem of claim 23, wherein said storage virtualization controller further

comprises at least one multiple-device device-side expansion port for accommodating an additional set of at least one PSD.

- [c35] 35. The storage virtualization subsystem of claim 23, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting point-to-point connectivity in target mode.
- [c36] 36. The storage virtualization subsystem of claim 23, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting private loop connectivity in target mode.
- [c37] 37. The storage virtualization subsystem of claim 23, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting public loop connectivity in target mode.
- [c38] 38. The storage virtualization subsystem of claim 23, wherein at least one said host-side IO device interconnect port is parallel SCSI operating in target mode.
- [c39] 39. The storage virtualization subsystem of claim 23, wherein at least one said host-side IO device interconnect port is ethernet supporting the iSCSI protocol operating in target mode.



- [c40] 40. The storage virtualization subsystem of claim 23, wherein at least one said host-side IO device interconnect port is Serial-Attached SCSI (SAS) operating in target mode.
- [c41] 41. The storage virtualization subsystem of claim 23, wherein at least one said host-side IO device interconnect port is Serial ATA operating in target mode.
- [c42] 42. The storage virtualization subsystem of claim 23 further comprising an enclosure management services mechanism.
- [c43] 43. The storage virtualization subsystem of claim 42, wherein said enclosure management services mechanism manages and monitors at least one of the following devices belonging to the storage virtualization subsystem: power supplies, fans, temperature sensors, voltages, uninterruptible power supplies, batteries, LEDs, audible alarms, PSD canister locks, door locks.
- [c44] 44. The storage virtualization subsystem of claim 42, wherein said enclosure management services mechanism is configured to support direct-connect EMS configuration.
- [c45] 45. The storage virtualization subsystem of claim 42, wherein said enclosure management services mechanism

is configured to support device-forwarded EMS configuration.

[c46] 46. The storage virtualization subsystem of claim 42, wherein said enclosure management services mechanism is configured to support direct-connect EMS configuration and device-forwarded EMS configuration.

[c47] 47. The storage virtualization subsystem of claim 42, wherein said enclosure management services mechanism is configured to support SES enclosure management services protocol.

[c48] 48. The storage virtualization subsystem of claim 42, wherein said enclosure management services mechanism is configured to support SAF-TE enclosure management services protocol.

[c49] 49. The storage virtualization subsystem of claim 42, wherein said EMS mechanism further comprises I2C latches to communicate with said storage virtualization controller.

[c50] 50. The storage virtualization subsystem of claim 42, wherein said EMS mechanism further comprises status-monitoring circuitry to communicate with said storage virtualization controller.

- [c51] 51. The storage virtualization subsystem of claim 42, wherein said EMS mechanism further comprises the following mechanism to communicate with said storage virtualization controller: I2C latches and status-monitoring circuitry.
- [c52] 52. The storage virtualization subsystem of claim 42, wherein said EMS mechanism further comprises a CPU for running a program.
- [c53] 53. The storage virtualization subsystem of claim 42, wherein said EMS mechanism further comprises at least one I2C interconnect as a primary communication media to said storage virtualization controller.
- [c54] 54. An external storage virtualization controller for executing IO operations in response to IO requests from a host entity, comprising:  
a central processing circuitry for performing IO operations in response to said IO requests of said host entity;  
at least one IO device interconnect controller coupled to said central processing circuitry;  
at least one host-side IO device interconnect port provided in a said at least one IO device interconnect controller for coupling to said host entity; and  
at least one device-side IO device interconnect port provided in a said at least one IO device interconnect con-

troller for coupling to and performing point-to-point serial-signal transmission with at least one physical storage device.

[c55] 55.The external storage virtualization controller of claim 54 wherein said device-side IO device interconnect controller comprises at least one Serial ATA port, each for connecting to a said at least one physical storage device through a Serial ATA IO device interconnect.

[c56] 56.The external storage virtualization controller of one of claims 54 and 55 wherein a said host-side IO device interconnect port and a said device-side IO device interconnect port are provided in the same IO device interconnect controller.

[c57] 57.The external storage virtualization controller of one of claims 54 and 55 wherein a said host-side IO device interconnect port and a said device-side IO device interconnect port are provided in different IO device interconnect controllers.

[c58] 58.The external storage virtualization controller of one of claims 54 and 55 wherein said device-side IO device interconnect controller further comprises a PCI/PCI-X interface for connecting to the central processing circuit.

[c59] 59.The external storage virtualization controller of one

of claims 54 and 55 wherein said device-side IO device interconnect controller further comprises a PCI Express interface for connecting to the central processing circuit.

[c60] 60. The external storage virtualization controller of one of claims 54 and 55, wherein said storage virtualization controller comprises a plurality of host-side IO device interconnect ports each for coupling to a host-side IO device interconnect.

[c61] 61. The external storage virtualization controller of one of claims 54 and 55, wherein said storage virtualization controller is configured for defining at least one logical media unit consisting of sections of said at least one PSD.

[c62] 62. The external storage virtualization controller of claim 60, wherein said storage virtualization controller is configured for presenting redundantly a logical media unit on at least two of said plurality of host-side IO device interconnect ports.

[c63] 63. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said PSD is a direct-access storage device (DASD) and said storage virtualization controller is configured for defining a logical media unit consisting of sections of at least one said

direct access storage device and said logical media unit is of RAID level or a combination of RAID levels, whereby said logical media unit is contiguously addressable by said host entity.

- [c64] 64. The external storage virtualization controller of one of claims 54 and 55 further comprising at least one multiple-device device-side expansion port for accommodating a second set of at least one PSD.
- [c65] 65. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting point-to-point connectivity in target mode.
- [c66] 66. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting private loop connectivity in target mode.
- [c67] 67. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said host-side IO device interconnect port is Fibre Channel supporting public loop connectivity in target mode.
- [c68] 68. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said host-side IO device interconnect port is parallel SCSI operating in

target mode.

- [c69] 69. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said host-side IO device interconnect port is ethernet supporting the iSCSI protocol operating in target mode.
- [c70] 70. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said host-side IO device interconnect port is Serial-Attached SCSI (SAS) operating in target mode.
- [c71] 71. The external storage virtualization controller of one of claims 54 and 55, wherein at least one said host-side IO device interconnect port is Serial ATA operating in target mode.
- [c72] 72. The external storage virtualization controller of one of claims 54 and 55 further comprising an enclosure management services mechanism.
- [c73] 73. The storage virtualization controller of claim 72, wherein said enclosure management services mechanism is configured to support direct-connect EMS configuration.
- [c74] 74. The storage virtualization controller of claim 72, wherein said enclosure management services mechanism

is configured to support device-forwarded EMS configuration.

[c75] 75. The storage virtualization controller of claim 72, wherein said enclosure management services mechanism is configured to support direct-connect EMS configuration and device-forwarded EMS configuration.

[c76] 76. The storage virtualization controller of claim 72, wherein said storage virtualization controller is configured to support SES enclosure management services protocol.

[c77] 77. The storage virtualization controller of claim 72, wherein said storage virtualization controller is configured to support SAF-TE enclosure management services protocol.

[c78] 78. A method for performing storage virtualization in a computer system with an external storage virtualization controller of the computer system, comprising:  
receiving an IO request from a host entity of the computer system with the storage virtualization controller;  
parsing the IO request with the storage virtualization controller to decide at least one IO operation to perform in response to said IO request; and  
performing at least one IO operation with the storage



virtualization controller to access at least one physical storage device of the computer system in point-to-point serial-signal transmission.

[c79] 79. The method of claim 78 wherein the point-to-point serial-signal transmission is performed in a format complying with a Serial ATA protocol.

[c80] 80. The method of one of claims 78 and 79 further comprising the step of providing an enclosure management services mechanism.

[c81] 81. The method of claim 80 further comprising the step of executing said enclosure management services mechanism when said mechanism is configured to support direct-connect EMS configuration.

[c82] 82. The method of claim 80 further comprising the step of executing said enclosure management services mechanism when said mechanism is configured to support device-forwarded EMS configuration.

[c83] 83. The method of claim 80 further comprising the step of executing said enclosure management services mechanism when said mechanism is configured to support direct-connect EMS configuration and device-forwarded EMS configuration.

- [c84] 84. The method of claim 80 further comprising the step of executing said enclosure management services mechanism when said storage virtualization controller is configured to support SES enclosure management services protocol.
- [c85] 85. The method of claim 80, further comprising the step of executing said enclosure management services mechanism when said storage virtualization controller is configured to support SAF-TE enclosure management services protocol.
- [c86] 86. The method of one of claims 78 and 79, wherein at least one said PSD comprises a SATA PSD.
- [c87] 87. The method of one of claims 78 and 79, wherein at least one said PSD comprises a PATA PSD and serial signals in said serial signal transmission are converted by a serial-to-parallel converter to parallel signals compliant with said PATA PSD.
- [c88] 88. The method of one of claims 78 and 79, wherein the step of performing said at least one IO operation comprises issuing at least one device-side IO request to said device-side IO device interconnect controller and reformatting said device-side IO request and accompanying IO data into at least one data packet for transmis-

sion.

- [c89] 89. The method of claim 88, wherein said data packet comprises a start segment at the beginning indicating the start of said data packet, an end segment at the end indicating the end of the data packet, a payload data segment containing actual IO information to transmit through the device-side IO device interconnect, and a check data segment containing check codes derived from said payload data for checking the correctness of said payload data after transmission.
- [c90] 90. A computer-readable storage medium having a computer program code stored therein that is capable of causing a computer system having an external storage virtualization controller and at least one physical storage device connected to the storage virtualization controller to perform the steps of:
- receiving an IO request from a host entity of the computer system with the storage virtualization controller;
  - parsing the IO request with the storage virtualization controller to decide at least one IO operation to perform in response to said IO request; and
  - performing said at least one IO operation with the storage virtualization controller to access said at least one physical storage device in point-to-point serial-signal transmission.

- [c91] 91. The computer-readable storage medium of claim 90 wherein the point-to-point serial-signal transmission is performed in a format complying with a Serial ATA protocol.
- [c92] 92. The computer-readable storage medium of one of claims 90 and 91, wherein a said PSD comprises a SATA PSD.
- [c93] 93. The computer-readable storage medium of one of claims 90 and 91, wherein a said PSD comprises a PATA PSD and serial signals in said serial signal transmission are converted by a serial-to-parallel converter to parallel signals compliant with said PATA PSD.
- [c94] 94. The computer-readable storage medium of one of claims 90 and 91, wherein the step of performing said at least one IO operation comprises issuing a device-side IO request to said device-side IO device interconnect controller and re-formatting said device-side IO request and accompanying IO data into at least one data packet for transmission.
- [c95] 95. The computer-readable storage medium of claim 94, wherein said data packet comprises a start segment at the beginning indicating the start of said data packet, an end segment at the end indicating the end of the data

packet, a payload data segment containing actual IO information to transmit through the device-side IO device interconnect, and a check data segment containing check codes derived from said payload data for checking the correctness of said payload data after transmission.